

Traffic Signals Manual
December, 1999
Manual Notices
Manual Notice 99-1

To: Recipients of Subject Manual

From: Carlos A Lopez, P.E.
Traffic Operations Division

Manual: *Traffic Signals Manual*
(Traffic Operations Collection)

Date: November 3, 1999

Purpose

This manual provides information on and internal procedures and practices related to traffic signals.

Supersedes

This manual supersedes:

- ◆ Part 2 of the *Traffic Engineering Procedures Manual*, "Traffic Signal and Illumination Procedures" (the portions dealing with traffic signals)
- ◆ Administrative Circular No. 54-86, "Traffic Signal Recommendation Form Revision."

Contents

This distribution of the *Traffic Signals Manual* contains:

- ◆ this manual notice
- ◆ Table of Contents
- ◆ Chapters 1 through 5
- ◆ Appendix A
- ◆ Appendix B

- ◆ Index
- ◆ divider tabs
- ◆ a front cover insert
- ◆ a spine insert.

Instructions

This is a new manual. Insert these chapters and related matter with tabs into a three-ring binder.

Effective Date

This manual notice is effective as of December 1, 1999.

Review History

User Review. Selected potential users in all TxDOT districts reviewed and commented on the draft of this manual.

In addition to the district personnel, the following divisions reviewed drafts of this manual:

- ◆ Construction Division
- ◆ Design Division
- ◆ General Services Division
- ◆ Maintenance Division
- ◆ Transportation Planning and Programming Division.

We received numerous comments and suggestions, from the various reviewers. Changes and additions were made to the final draft as appropriate.

General Counsel Review. The Office of General Counsel reviewed a late draft of this manual and suggested some changes and additions, which we incorporated as appropriate.

Audit Office Review. The Audit Office reviewed a late draft of this manual and suggested some changes and additions, which we incorporated as appropriate.

Contact

Address questions concerning information contained in this manual notice to James Kratz, Traffic Operations Division (TRF), 512-416-3225 or fax 512-416-3161.

Copyright Notice

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Chapter 1

Introduction

Contents

This chapter contains the following sections:

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Section 1

Overview

Scope of this Manual

This manual is a guide and reference for the handling of requests for traffic signals on the designated State Highway System, including installations financed by federal funds and installed off the numbered State Highway System.

This manual describes the steps necessary for the installation of traffic signals, from project inception through construction and final disposition of records.

Traffic Signal Policy

The State Highway and Public Transportation Commission (now known as the Texas Transportation Commission) approved TxDOT's current policy on highway traffic signals under Commission Minute Order No. 85777 dated May 27, 1987. The current policy, as published in the *Texas Administrative Code*, under TAC 43, Section 25.5, states that TxDOT:

- ◆ may install, maintain, and operate traffic signals on the state highway system in unincorporated areas when requested by anyone and provided that the location or locations meets one or more of the warrants for highway traffic signals contained in the current *Texas Manual on Uniform Traffic Control Devices for Streets and Highways (TMUTCD)*
- ◆ may install, maintain, and operate traffic signals on the state highway system in incorporated cities of less than 50,000 population (latest federal census) when requested by the city council, mayor, city manager, or any authorized city official and on frontage roads and at interchanges of freeways of the state highway system within incorporated cities and provided that the location or locations meet one or more of the warrants for highway traffic signals contained in the current *TMUTCD* and that the city enters into an agreement setting forth the responsibilities of each party
- ◆ is responsible for authorizing traffic signals to be installed at locations on the state highway system other than freeways in incorporated cities of 50,000 or more population (latest federal census) provided that the location or locations meet one or more of the warrants for highway traffic signals contained in the current *TMUTCD*
(NOTE: The cost of installation, operation, and maintenance of these signals is the responsibility of the city, except that TxDOT may provide for the installation of traffic signals when the installation is financed in part with federal-aid funds and the city enters into an agreement setting forth the responsibilities of each party. See the *Traffic Engineering Agreements Volume* of the *Traffic Operations Manual* for details.)

- ◆ may install, maintain, and operate traffic signals on state highway frontage roads in all areas, provided the locations meet at least one of the *TMUTCD* warrants.
(NOTE: The maintenance and operation of these signals may be contracted out to cities.)

The Texas Manual on Uniform Traffic Control Devices (TMUTCD)

Section 544.001 of the Texas Transportation Code requires TxDOT to adopt a manual and specifications for a uniform system of traffic control devices for use on streets, roads, and highways within the state. The uniform system must correlate with and, so far as possible, conform to the system then current as approved by the Federal Highway Administration (FHWA) and set forth in the *National Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)*. The *Texas Manual on Uniform Traffic Control Devices (TMUTCD)* basically follows the national *MUTCD*, except where the national standards conflict with state law or where modifications are necessary to more closely fit Texas conditions. The 1980 *TMUTCD* was adopted by Commission Minute Order No. 77548 on July 21, 1980, referenced in the Texas Administrative Code found in Title 43 TAC, Section 25.1.

Using the TMUTCD

The *TMUTCD* is referenced throughout this manual. The *TMUTCD* contains the standards and basic principles governing the design and usage of traffic control devices in Texas. The provisions of the *TMUTCD* apply to all streets and highways in the state, including those under the jurisdiction of cities and counties. It should be the governing document on any question regarding the application of traffic control devices.

Part IV of the *TMUTCD* provides detailed information and guidelines on traffic signal applications, including minimum warrants required for traffic signal installation. Readers are urged to consult the *TMUTCD* for information and topics not covered in this manual, which only provides additional information specific to TxDOT operations.

Obtaining Copies of the *TMUTCD*

Contact TxDOT's Traffic Operations Division (TRF) to obtain copies of the *TMUTCD*. Certain public entities outside TxDOT may be entitled to complimentary (free) copies of the *TMUTCD*, depending on their responsibility to the general public in the area of traffic planning and operations. Complimentary copies are sent directly to the requesting entity according to the criteria in the following table.

<i>TMUTCD</i> — Complimentary Distribution	
Entity or Individual	What They Get
All Texas incorporated cities of 5,000 or more population	<ul style="list-style-type: none"> ◆ one copy for city administration ◆ one additional copy, upon request, if the city has a traffic engineering organization or other department responsible for traffic planning and operations.
All Texas incorporated cities under 5,000 population	one copy sent to city administration.
All Texas Counties	one copy sent to the county commissioners' court.
The executive and legislative branches of the state	copies when requested for state business.
All courts above district courts in the Judicial Branch	copies when requested for state business.
Federal Highway Administration personnel having a need	copies upon request.
Official highway and public transportation organizations having a need (such as the American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, National Committee on Uniform Traffic Control Devices, Highway Transportation Research Board, National Safety Council, and others of similar status)	copies upon request.
All Texas state agencies having a need, such as the Department of Public Safety and others of similar status	copies upon request.
All other official governmental agencies, such as other states, foreign countries, and others of similar status	copies upon request.

Traffic Signal Agreements

Agreements of various kinds are often required for traffic signal installations. For information on when traffic signal agreements are required and how they are handled, see the *Traffic Engineering Agreements Volume* of the *Traffic Operations Manual*.

Traffic Signal Project Process Overview

Before proceeding to construction, a traffic signal project on the state highway system progresses through the following stages:

1. Someone, either inside or outside TxDOT, requests the signal installation.
2. The district acknowledges the request.
3. The district or city conducts a traffic study to determine if the signal is warranted and justified.
4. The district or city designs the installation.
5. The district submits the design and signed signal authorization forms to TRF for review.

Section 2

Traffic Operations Division Support

TRF Liaison

The Traffic Operations Division (TRF) designates a contact liaison within the division for traffic signal issues for each district. The liaisons serve as the first point of contact for the districts on traffic signal issues. Generally the TRF liaison is the traffic operations field area head for the particular area of the state.

TRF Support Functions

TRF supports district signal design and operation activities. Support is available in the following areas:

- ◆ plan, specification, and estimate (PS&E) review
- ◆ operational matters, such as traffic signal phasing and timing
- ◆ technical issues (such as controllers and detectors), including:
 - writing and maintaining equipment specifications
 - performing equipment inspection and testing for the General Services Division (GSD) and district contract jobs
 - consulting with districts regarding traffic signal design applications
- ◆ field support, including system installation and troubleshooting.

Signal System Analysis

TRF can provide system analysis using:

- ◆ Passer2 for arterial signal timing
- ◆ Passer3 for diamond interchange controllers
- ◆ Passer4 for arterial and network timing optimization
- ◆ Transyt for arterial and network analysis
- ◆ Highway Capacity Software (HCS) for capacity analysis.

Specification Writing and Maintenance

TRF writes and maintains technical specifications for traffic signal equipment for use on contract jobs and for equipment purchased through GSD. TRF also assists districts in developing technical specifications for one-time or district-wide use for items not covered by the standard specifications. Specifications for which TRF is responsible include:

- ◆ traffic signal controllers and cabinets
- ◆ signal hardware, such as signal heads and lamps
- ◆ closed loop systems
- ◆ and vehicle detectors.

NOTE: For all items that have statewide specifications available these standard specifications should be used.

Equipment Testing for General Services

TRF performs the functional and environmental tests for equipment purchased by the General Services Division (GSD) to make sure it meets specifications.

Section 3

Equipment Acquisition

Acquisition Methods

Districts can acquire traffic signal equipment by any of the following methods:

- ◆ through the GSD general warehouse
- ◆ through small purchases
- ◆ through blanket orders
- ◆ through construction contracts.

Explanations of each of these methods follow.

Acquisition through GSD General Warehouse

Equipment obtained through the GSD general warehouse provides uniformity and quick purchase time. This is the most economical way to purchase equipment, because warehouse stock is purchased in larger quantities. Districts may order equipment from the general warehouse by submitting a request using the on-line Materials and Supply Management System (MSMS). (See the *MSMS User Manual* for details.) A TxDOT catalogue number (DHT number) is required. Stock equipment is issued on a first-come-first-serve basis.

Acquisition through Small Purchase

Equipment not stocked in the general warehouse can be obtained through either a small purchase or a blanket order. The small purchase is most useful and practical for infrequently purchased items (items purchased once or twice a year). Small purchases can often be done directly by the district, depending on the amount of the purchase. Three bids are required for a small purchase, unless a sole source purchase justification is submitted to GSD. Purchases of equipment over \$15,000 are handled by GSD.

Acquisition through Blanket Order

Blanket orders can be established for items more commonly purchased (equipment purchased on a small purchase basis several times a year). This type of purchase procedure also promotes equipment uniformity. Blanket purchases generally are made through GSD, and delivery is made directly to the district requesting the equipment. Since the bids are obtained before the specific request from a district, the delivery time is typically shorter than for a small purchase.

Acquisition through Construction Contract

Traffic signal equipment may be acquired through construction contracts by any of the following three means:

- ◆ The contractor may supply the traffic signal equipment.
- ◆ The state may furnish the traffic signal equipment. With this method, the state purchases the traffic signal equipment through the general warehouse, small purchase, or blanket order and provides the equipment to the contractor for installation.
- ◆ When a traffic signal is being installed in a city, the city may supply the traffic signal equipment to the contractor for installation.

Coordinating First Time Purchases with TRF

Whenever new traffic signal equipment is purchased for the first time, the purchase should be coordinated with the Traffic Operations Division (TRF) to ensure that all TxDOT districts and divisions become aware of the experiences with and testing done on the product. This coordination helps maintain uniformity across the state and reduces duplication of effort between districts and divisions.

Equipment Testing

Equipment must undergo environmental testing at TRF in Austin as specified. Equipment that is not on a prequalified list must also go through functional testing at either the district or TRF in Austin. This testing is in addition to the environmental testing.

If the equipment is supplied by the state through the GSD purchasing system, it has already been through both the functional and environmental tests. Such equipment is also purchased in larger numbers and can provide significant cost savings.

Product Prequalification

The equipment testing performed by TRF includes the evaluation of new products and testing products for prequalification. Prequalification reduces the time required to test pre-shipment samples and the duplication of effort between the districts and division.

Equipment for Contract Jobs

Equipment on contracted projects can be supplied by the contractor, state, or city.

If the equipment is supplied by the contractor, it must be thoroughly checked to verify that it meets all pertinent specifications. Prequalification of traffic signal equipment does not eliminate the need for testing. Testing is the only assurance that the equipment will function as specified when it is installed at the intersection.

Chapter 2

Requests for Traffic Signals

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Section 1

Sources of Requests

Introduction

Requests for traffic signal installations may originate from either of the following sources:

- ◆ routine operations within the district
- ◆ special requests from outside the district or the department.

From Within the District. TxDOT personnel should be sufficiently aware of conditions on all highways in their respective districts in order to initiate requests through the district traffic engineer for studies at locations where the need for an installation appears evident.

From Outside the District. A request for a traffic signal installation may be initiated by any of the following parties outside of the district:

- ◆ a private citizen
- ◆ a private organization
- ◆ a public organization
- ◆ a city
- ◆ a county
- ◆ a division or section of TxDOT
- ◆ another state agency.

Requests from Unincorporated Areas

Individuals. In unincorporated areas, requests from individuals and public or private organizations should be by letter, preferably with a discussion of the apparent problem or hazard.

Counties. Requests from a county should be by official letter from the county judge, or by resolution of the county commissioners court.

Requests from Incorporated Areas

At locations in incorporated areas, requests should be made through the proper city authority, such as the city council, mayor, or city manager. The request should be forwarded in the form of a letter to the TxDOT district. The letter should be accompanied by:

- ◆ a discussion of the apparent problem or hazard
- ◆ a condition diagram, accident collision diagram, or other applicable reports
- ◆ traffic volume data, as may be obtained from the city's traffic engineering department.

Requests from Private Organizations

Normally, traffic signals are not installed at intersections of private driveways with state routes. A private driveway intersecting a state route requires a driveway permit. The issuance of a driveway permit should be contingent on the TxDOT's approval of an impact study of the area to be developed. This impact study should include a traffic signal study. If the signal study indicates that the proposed development will create enough traffic to cause undue traffic delays and hazards, then the district notifies the private organization that a traffic signal must be installed before the driveway is opened to the public.

If a traffic signal is authorized at a private driveway, the private driveway should have sufficient channelization, acceleration and deceleration lanes, or pavement markings at the intersection.

Funding. TxDOT does not fund the installation of traffic signals for private driveways intersecting state routes. The private organization must fund the installation of the traffic signal through a three party agreement.

Section 2

Action on Requests

Districts Act on Requests

When a request for a traffic signal installation is received by TxDOT, it must be acted upon by the appropriate district. If the request is received by any office other than the district office responsible for the location, it should be forwarded to the appropriate district for handling.

Acknowledgment of Request

Should a district office or the Traffic Operations Division (TRF) receive the request initially, the requesting party or agency should be informed, by letter, that the request has been received and is being studied.

Process Overview

After acknowledging receipt of a signal request, the district does the following:

1. The district conducts a traffic engineering study (if the city has not already provided this information) to determine if the location meets one of the signal justification warrants in the *Texas Manual on Uniform Traffic Control Devices (TMUTCD)*. (See Chapter 3 of this manual, which describes the traffic study.)
2. If the traffic study shows that the location meets at least one of the warrants for traffic signal installation (as described in the *TMUTCD*), the district then decides, based on engineering judgment, if the installation of a traffic signal would be in the best interest of the public. If the location does not meet at least one warrant, the request is denied.
3. If the traffic signal installation is deemed appropriate, the district traffic section then forwards its recommendation and a Traffic Signal Authorization Request form (described in [Chapter 5](#) of this manual) to the district engineer for final approval and signature.
4. If the signal installation is approved, the district then determines who is responsible for the installation of the signal (based on the “[Traffic Signal Policy](#)” outlined in Chapter 1, Section 1, of this manual). If funding, installation, maintenance, or operation of the proposed signal will involve an entity other than TxDOT, the district must determine if a written agreement is required. Traffic signal agreements are covered in the *Traffic Engineering Agreements Volume* of the *Traffic Operations Manual*.

Chapter 3

Traffic Studies

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Section 1

Overview

Introduction

A traffic study consists of a comprehensive investigation of existing physical and operating conditions. Analysis of the study data provides insight into possible remedial measures, if any. Remedial measures may include various traffic control measures, such as speed zoning, channelization, signing, traffic signals, safety lighting, or a combination of these. This chapter pertains only to traffic studies which may result in the installation of traffic signals.

Responsibility

TxDOT is responsible for conducting traffic studies on numbered state routes, locations within incorporated with populations less than 50,000, and on interstate frontage roads. Incorporated cities with populations greater than 50,000 should conduct their own traffic studies.

Districts normally conduct traffic studies (as described in Sections 2 through 8 of this chapter). Traffic study information is then submitted to the district engineer for review and approval, as described in Section 8 of this chapter.

Costs

Normally the costs for conducting traffic studies are absorbed into the operations of the districts. However, traffic study costs for federal-aid projects are reimbursable by the Federal Highway Administration (FHWA), if a control section job number has been assigned by the Transportation Planning and Programming Division (TPP).

Required Information

A complete traffic study for a proposed traffic signal or flashing beacon installation requires the collection of sufficient data on the physical, traffic, and operational characteristics of the intersection. Some of the data is difficult and time consuming to collect. Examples of the types of data typically collected are:

- ◆ condition diagram (covered in Section 2 of this chapter)
- ◆ location map (covered in Section 3 of this chapter)
- ◆ photographs (covered in Section 3 of this chapter)
- ◆ accident (crash) information (covered in Section 4 of this chapter)
- ◆ vehicular and pedestrian traffic counts (covered in Section 5 of this chapter)
- ◆ approach speeds (covered in Section 6 of this chapter)
- ◆ Traffic Survey Count Analysis Form (covered in Section 7 of this chapter)
- ◆ intersection delay study (covered in Section 8 of this chapter).

When the traffic signal study is complete, the information is tabulated and checked against the traffic signal warrants set forth in the *Texas Manual on Uniform Traffic Control Devices (TMUTCD)*. The district traffic section supervisor then makes a recommendation to the district engineer using the Traffic Signal Authorization Request form (as described in [Chapter 5](#) of this manual).

Warrant Analysis Data

Research Report 3991-2F (“Traffic Signal Warrants: Guidelines for Conducting a Traffic Signal Warrant Analysis,” sponsored by TxDOT in cooperation with US DOT and FHWA) suggests that the data for traffic studies should be collected in five phases, which are associated with the traffic signal warrants. It is common to first analyze warrants requiring data that is easier to collect. If a signal does not meet any of these warrants, then the more difficult data is collected and the other warrants are analyzed. The following table shows the suggested phased data collection and associated warrants.

Suggested Phased Data Collection and Associated Warrants	
Phase	Warrants
Phase 1 — Volume Warrants	<ul style="list-style-type: none"> ◆ Warrant 1: Minimum Vehicle Volume ◆ Warrant 2: Interruption of Continuous Traffic ◆ Warrant 9: Four Hour Volumes ◆ Warrant 11: Peak Hour Volume ◆ Warrant 12: Warrant Volumes for Traffic Actuated Signals ◆ Warrant 8: Combination of Warrants
Phase 2 — Accident Warrant	<ul style="list-style-type: none"> ◆ Warrant 6: Accident Experience
Phase 3 — Signal Operation Warrants	<ul style="list-style-type: none"> ◆ Warrant 5: Progressive Movement ◆ Warrant 7: Systems
Phase 4 — Delay Warrant	<ul style="list-style-type: none"> ◆ Warrant 10: Peak Hour Delay
Phase 5 — Pedestrian Warrants	<ul style="list-style-type: none"> ◆ Warrant 4: School Crossing ◆ Warrant 3: Minimum Pedestrian Volume.

Section 2

Condition Diagram

Introduction

A study should be made of existing conditions at the study location and along each approach to it. Where the location is open to traffic, the study should include existing traffic control devices (signs, signals, markings, speed zones, etc.).

Information Sources

The condition diagram should provide a complete presentation of the physical layout of the study location as it currently exists.

Plan Sheets from Prior Projects. Final construction plan sheets from prior projects may be used as a basis for the condition diagram.

Aerial Photographs. The Information Systems Division (ISD) will prepare, on request, the condition diagram from aerial photographs. However, due to the expense of obtaining aerial photographs, districts seldom make this request. ISD prepares condition diagrams at scales shown in the following table.

Scales Available for Condition Diagrams	
English Scale	Approximate Metric Equivalent Scale
1 inch = 20 feet	1:200
1 inch = 50 feet	1:500
1 inch = 100 feet	1:1000

Additional Necessary Information

The following items should be included in the condition diagram:

- ◆ north cardinal direction
- ◆ highway and intersection design features, including:
 - pavement edges, curbs, and shoulders (unpaved or paved)
 - widths of approaches
 - approach grades
 - channelization
 - parking conditions and restrictions
 - bus stops
 - safety lighting or continuous lighting
 - any other roadway features which may affect traffic operations
- ◆ roadside development, including:
 - sight distance restrictions (trees, bushes, advertising and other signs, poles, fences, bridge, and guard rails)
 - off street parking
 - driveway locations
 - utility and other poles
 - adjacent land use
 - any other pertinent features
- ◆ traffic control devices, such as:
 - signs
 - traffic signals (type, face locations, etc.)
 - distance to adjacent traffic signals within 1.61 km (one mile) (indicate if none)
 - pavement markings
 - any other traffic control devices
 - railroad crossing and type of control
 - distance to railroad from traffic signal.

Section 3

Location Map and Photographs

Location Map

A city or area location map should be prepared to show the relationship of the proposed installation to other traffic signals, highways, business areas, and traffic generators.

Photographs

Photographs should be made of all approaches to an intersection, ramp, or any other location being studied for a traffic signal. Generally, only one photograph is necessary for each approach if the photograph is taken from a position approximating that of a passenger car driver approaching the intersection. This would normally be from 46 to 91 m (150 to 300 feet) from the study location. More than one photograph may be required for a particular approach to fully illustrate problems at the location. Peripheral features may also be helpful in defining any operational problems.

The location and approach view direction of each photograph should be indicated on the photograph itself.

Section 4

Accident (Crash) Information

Introduction

Accident (crash) information for traffic studies is obtained primarily through mainframe computer reports. (For additional information on accident or crash information, see the *Traffic Accident Information and Hazard Elimination Volume* of the *Traffic Operations Manual*.)

Mainframe Computer Reports

All TxDOT personnel with access to the mainframe computer may obtain various accident (crash) information reports through Remote Job Entry Job Control Language (RJEJCL) on ROSCOE. The following table explains the five types of reporting programs and the data accessible through them.

TxDOT Mainframe Reporting Programs Providing Accident (Crash) Information		
Reporting Program	Description	Data Accessible
Master Accident Listing (MAL)	Standard traffic accident information report produced by TxDOT.	Three full years, plus currently available months of most recent year.
Collision Plot Diagram — Section Plot	Provides a pictorial representation of each accident from Point A to Point B. (Some accidents may not be diagrammed if location or direction information is missing.)	Three full years, plus currently available months of most recent year.
Collision Plot Diagram — Intersection Plot	Provides a pictorial representation of each accident at an intersection. (Some accidents may not be diagrammed if location or direction information is missing.)	Three full years, plus currently available months of most recent year.
Resurfacing, Restoration, and Rehabilitation Report (RRR Report)	Provides traffic accident information in a format to support the review of locations for inclusion in the federally funded RRR construction program.	Three full years, plus currently available months of most recent year.
Traffic Accident Records System (TARS)	Provides subsetting capability for analysis of traffic accident information. Three report formats are included. All reporting provides information in word phrases. No decoding is required.	Nine full years, plus currently available months of most recent year.

Users should direct questions concerning these programs to their information resource administrator or to the Traffic Operations Division (TRF).

Booklets that guide users step-by-step through the process of obtaining these RJEJCL reports are available from TRF. Users should ask for any or all of the following:

- ◆ “How to Obtain a Master Accident Listing”
- ◆ “How to Obtain a Section Collision Plot Diagram”

- ◆ “How to Obtain an Intersection Collision Plot Diagram”
- ◆ “How to Obtain a RRR Report”
- ◆ “Traffic Accident Records System.”

NOTE: Since the Texas Department of Public Safety (DPS) is the agency of record for traffic accident information, requests for information from the general public should be routed to DPS. However, when TxDOT is required to produce traffic accident information, the Master Accident Listing is the standard report provided.

Specialized Analyses and Customized Reports

TRF staff can assist districts or other divisions in performing specialized analyses or in customizing reports. When existing reporting formats do not provide appropriate summaries or additional historical data are needed, contact TRF.

Officer’s Report from DPS

When coded information is not sufficient, copies of an officer’s report may be obtained from the Department of Public Safety (DPS). TRF can provide information to assist DPS in searching for a copy of the report.

Section 5

Vehicle and Pedestrian Traffic Counts

Introduction

Up-to-date traffic and pedestrian volume counts reflect the characteristics of traffic. These volume counts, when compared to the established warrants, help determine the appropriate type of traffic control device, if any.

Types of Counts

A volume count analysis may use the following types of counts:

- ◆ vehicle counts at existing locations
- ◆ estimated counts at locations under construction and projected counts for future locations
- ◆ pedestrian counts
- ◆ school pedestrian counts.

Discussions of each of these types of counts follow.

Volume counts should be shown on the Traffic Survey Count Analysis Sheet (discussed in Section 7 of this chapter) for review in the office following the field work.

Vehicle Counts at Existing Locations

A vehicle count at an existing location should include the number of vehicles entering the location on each approach. Counts are recorded as vehicles cross the stop bar and enter the intersection. Tallies should be recorded for each quarter hour for the duration of the count. Ideally, counts are conducted on a “representative day” (defined later). The duration of the count should be 16 consecutive hours. This time span should contain the greatest percentage of traffic during the 24-hour time period. Traffic patterns, such as when the highest vehicle and pedestrian volumes occur, should help determine the beginning and ending times for the count. These patterns may vary from one location to the next.

Representative Day. A representative day is normally an average, mid-week day, such as Tuesday, Wednesday, or Thursday. Monday or Friday may be acceptable if traffic volumes are representative of a mid-week day. Local knowledge of commercial habits, such as early closings or evening shopping, is essential in choosing a truly representative day. Under unusual conditions when recreational traffic is significant, traffic counts taken on weekends may be compared against the accepted warrants.

Counting Techniques

With passenger or commercial vehicles, manual turning movement counts are always preferable, as they provide both the basic data for justification as well as detailed guidance for design. When 16-hour, machine-recorded traffic counts are used for traffic signal studies, they should be supplemented with manual counts for two hours of the morning peak and two hours of the afternoon peak periods.

Recording Manual Counts

Manual traffic counts may be recorded on either the Vehicle Volume Summary Sheet or the Vehicle Volume Field Sheet. Samples of both these forms are provided in Appendix A of the hard copy print version of this manual. These sample forms may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division (TRF). In the on-line version of this manual, an MS Word version of the Vehicle Volume Summary Sheet may be opened and printed out by clicking on either of the following file name:

- ◆ **TFF-VVS** (for 4-way intersections)
- ◆ **TFF-VVS5** (for 5-way intersections).

Estimated and Projected Counts

For locations under construction or not yet in existence, the Transportation Planning and Programming Division (TPP) estimates the anticipated average daily traffic (ADT) volumes at the districts' request. To aid TPP in making such an estimate, 24-hour machine counts should be made along each approach open to traffic. An up-to-date map of the area and a layout of the location as it will be constructed should also be provided. (If construction will be staged and the location opened to traffic in increments, layouts at various stages of construction are recommended.) If a major traffic generator (shopping center, industrial plant, recreational facility, school, etc.) is in operation (or expected) within a 0.8 km (0.5 mile) radius of the location, the information should be included in the request to TPP.

Using the projected ADT volumes, the following general guidelines can be used to obtain an estimate of vehicle count data:

The maximum 8-hour volume is generally between 50 percent and 60 percent of the ADT, with the average being approximately 52 percent. In an urban area with a high ADT, the percentage is generally between 55 and 60 percent.

The average hourly volume of the maximum 8-hour volume is generally between 6 percent and 8 percent of the ADT (maximum 8-hour volume divided by eight.)

The lowest hourly volume (eighth highest hour) of the maximum 8-hour volume is generally between 5 percent and 6 percent of the ADT with an average value of approximately 5.5 percent. It is also approximately 80 percent of the average hourly volume or 10 percent of the maximum 8-hour volume. This value is the basis for comparing the anticipated volumes with the volume warrants for signalization found in the *Texas Manual on Uniform Traffic Control Devices*.

The lowest hourly volume (eighth highest hour) for a “grid system” of existing signals within a city is assumed to be 5.0 percent of the ADT.

The peak hour volume (highest hour) is generally between 6 percent and 10 percent of the ADT. The lower values are generally found on roadways with low volumes. The average value is approximately 8.4 percent of the ADT.

Pedestrian Counts

Pedestrian volume counts for each cross walk should be made during the same period as the vehicle volume count. Tallies should be recorded for each quarter hour for the duration of the count.

Pedestrian counts are not required in sparsely settled rural areas or at other locations where it is apparent that pedestrian movement is negligible. The signal installation must comply with the latest version of the Americans with Disabilities Act and the Texas accessibility standards.

Forms. The Pedestrian Volume Field Sheet and the Pedestrian Volume Summary Sheet can be used to record pedestrian counts in the field. Samples of these forms are provided in Appendix A of the hard copy print version of this manual. These sample forms may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division (TRF). In the on-line version of this manual, an MS Word version of the Pedestrian Volume Summary Sheet may be opened and printed out by clicking on either of the following file names:

- ◆ **TFF-PVS** (for 4-way intersections)
- ◆ **TFF-PVSS** (for 5-way intersections).

Count Data Handling. The pedestrian count data can be input with the vehicular volume counts into the mainframe Intersection Traffic and Pedestrian Count Analysis Program discussed in Section 7 of this chapter.

NOTE: As of this writing, Revision 5 to the *Texas Manual on Uniform Traffic Control Devices (TMUTCD)* has not been incorporated into the program.

School Pedestrian Counts

School pedestrian counts should be made on a normal school day during the hours of greatest crossing activity. Obtaining the necessary count information for a school crossing study involves:

- ◆ counting the number of vehicles
- ◆ determining the length and spacing of gaps in the traffic stream
- ◆ measuring the width of the street
- ◆ counting the number of pedestrians crossing the street during each gap in the traffic stream.

Other factors to be considered at the crossing are:

- ◆ the 85th percentile speed
- ◆ crash history
- ◆ existing pavement markings, signing and channelization
- ◆ the age of school children.

Forms. The necessary forms with instructions for conducting a school pedestrian count are:

- ◆ Pedestrian Group Size Study
- ◆ Pedestrian Delay Time Study.

Samples of these forms are provided in Appendix A of the hard copy print version of this manual. These sample forms may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division (TRF). In the on-line version of this manual, an MS Word version of these form may be opened and printed out by clicking on the following file name: [TFF-PGD](#).

For procedures for Determination of Need for Traffic Control at School Crossings, see Appendix B of this manual.

Section 6

Approach Speeds

Introduction

The 85th percentile speed on each of the approaches to the location should be determined. (See the TxDOT manual *Procedures for Establishing Speed Zones* for information on determining the 85th percentile speed.) Where approaches are controlled by a STOP sign or traffic signal at the time of the study, the speed check must be conducted far enough away from the location to obtain a speed not affected by the sign or signal.

Special Situations

At locations where a statewide statutory speed limit (70 mph) has been lowered, either by Transportation Commission minute order or city ordinance, the lowered speed limit may be acceptable as the approach speed.

At locations under construction, estimated approach speeds are acceptable.

Section 7

Traffic Survey Count Analysis

Count Data Processing

Vehicle and pedestrian count data must be tabulated and checked against established traffic signal warrants. The vehicle data are recorded on the Vehicle Volume Summary Sheets or the Vehicle Volume Field Sheets. The pedestrian data are recorded on the Pedestrian Volume Field Sheet or the Pedestrian Volume Summary Sheet.

The tabulation and checking can be accomplished manually or by using an automated system.

Manual Method. Manual tabulation is accomplished by transferring the data to the Traffic Survey — Count Analysis Form (discussed under the following subheading).

Automated Methods. Traffic count data may be transferred into an automated system for tabulation and checking against warrants. Districts may use commercially available software for this purpose or TxDOT's mainframe system, the Intersection Traffic and Pedestrian Count Analysis Program. (The mainframe program is discussed later in this section.)

The Traffic Survey — Count Analysis Form

The Traffic Survey — Count Analysis Form is used to compare the data from the traffic study with the accepted signal warrants. The form shows the following information:

- ◆ location data (major and minor street, control and section, etc.)
- ◆ date of survey
- ◆ 85th percentile speed on major street
- ◆ accepted traffic signal warrants
- ◆ vehicle and pedestrian volumes for the eight highest, *non-overlapping* hours of the day, as determined from the vehicle and pedestrian counts.

This form shows both rural and urban warrants; therefore, the warrants applied should be indicated on the form.

Form Available. A sample of this form is provided in Appendix A of the hard copy print version of this manual. This sample form may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division. In the on-line version of this manual, an MS Word version of this form may be opened and printed out by clicking on the following file name: [TFF-TSCA](#).

Intersection Traffic and Pedestrian Count Analysis Program

The Intersection Traffic and Pedestrian Count Analysis Program is a mainframe program that tabulates traffic counts made at intersections and checks the counts against established traffic signal warrants. The program is accessible for data entry and report generation through RJEJCL 19 in ROSCOE.

Pedestrian count data can be submitted with the vehicle count data. The approach speeds and number of lanes on each approach must be included on the computer input forms.

After data are entered, the program furnishes the following:

- ◆ printed Vehicle Volume Summary Sheets
- ◆ flow diagrams (unless requested otherwise) as follows:
 - Total Traffic Count
 - 15-minute A.M. Peak
 - 15-minute P.M. Peak
 - Peak Hour
 - Second Peak Hour
- ◆ computer-generated Traffic Survey Count Analysis Sheet (NOTE: as of this writing, Revision 5 to the *TMUTCD* has not been incorporated into this program)
- ◆ actuated warrant curve plots (1, 2, 4, and 8 high hours)
- ◆ graphs plotting vehicle volumes versus hours of day.

The Intersection Traffic and Pedestrian Count Analysis Program is maintained by the Information Systems Division (ISD). Questions concerning the program should be directed to the Traffic Operations Division (TRF).

Section 8

Intersection Delay Study

Introduction

To meet the requirements for Warrant 10, “Peak Hour Delay,” a delay study must be performed at the subject intersection. Typically, an intersection delay study is conducted at intersections or major driveways where congestion problems exist. This study is considered as a detailed investigation of the stopped-time delay conditions at an intersection being evaluated for signalization.

Time of Study

The intersection delay study should be performed during periods of congestion. Typically, the peak delay occurs during the peak hour, which can be identified from the traffic counts. The peak delay may occur during the major street’s peak hour or during the minor street’s peak hour, so care should be taken when determining the study time period. In some cases, both time periods need to be studied to determine the peak delay hour. It may be desirable to start the delay study 30 minutes before the beginning of the peak hour and end it 30 minutes afterwards to ensure that the peak delay is recorded.

Equipment

Unless the district has a delay meter, the intersection delay data is usually collected manually. In most cases, one observer is required for each intersection approach being evaluated. In some cases, traffic volumes are too heavy for one person to handle alone, and a second observer is used.

Each observer needs

- ◆ a stop watch or wristwatch with a second hand
- ◆ a clipboard and paper to record the delay data.

Form

The Intersection Delay Study Field Sheet can be used to record the data. A sample of the form is provided in Appendix A of this manual. This sample form may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division. In the on-line version of this manual, an MS Word version of this form may be opened and printed out by clicking on the following file name: [TFF-IDS](#).

Procedure

Performing a delay study involves counting the vehicles stopped in the intersection approach at successive intervals.

Selecting the Interval. The typical duration for the interval is 15 seconds. Other values can be selected; however, if a larger interval is selected, the amount of overestimation of delay increases. Conversely, if a smaller interval is selected, the amount of overestimation of delay is lower, but the amount of data collected increases. So the 15 second interval represents a good compromise.

Preparing the Form. Before the start of the study, the identifying information is entered in the appropriate places on the Intersection Delay Study Form. The first column is completed to indicate the starting times in minutes for the indicated succession of sampling intervals.

Counting and Recording. When the starting time arrives, the observer counts and records the number of vehicles stopped on the approach for each observation time indicated. As a vehicle arrives, it is recorded on the “Total Number of Vehicles” section in the column corresponding to the 15 second interval when the vehicle arrived. For example, if a vehicle arrived at 8:00.08 am, it is recorded in the column “+ 0 sec.” If this same vehicle is still waiting at the stop line at 8:00.15 am, it is recorded in the column “+ 15 sec.” Thus, a vehicle is counted more than once in the delay determination if it is stopped during more than one sampling time.

A separate tabulation of the approach volume is made for each time period by classifying vehicles as stopped or not stopping. (Note: the vehicles not stopping column is typically used for a delay study of an existing signalized intersection.) The number of stopping vehicles is always equal to or less than the total number of vehicles stopped on the approach for a specific time interval, because vehicles can be delayed for more than one sampling period.

Study Results

Each vehicle counted in the delay study is assumed to be stopped for the duration of the selected interval (typically 15 seconds). Each column is added up in each of the subtotal blocks, and the total is recorded in the “Total” block. The total number of vehicles delayed is then multiplied by the interval (15 seconds) to get total vehicle-seconds of delay. Then the highest four consecutive 15 minute time periods are added together. This sum is then divided by 3600 to convert the value to vehicle-hours of delay. The result is then used to determine if Warrant 10, “Peak Hour Delay,” is met.

Chapter 4

Operational Considerations

Contents

This chapter contains the following sections:

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Section 2 — Coordinated Operation	4-4
Section 3 — Preemption	4-6
Section 4 — Flashing Operation	4-7

Section 1

Overview

Introduction

How a traffic signal will be operated and maintained needs to be considered along with the initial design and installation. This chapter covers several operational considerations, including coordination, preemption, and flashing operation. How a traffic signal interacts with adjacent signals, railroads, and emergency vehicles is important to the effectiveness of the transportation system.

Equipment Repair

Failed equipment should be repaired by qualified personnel only. If the equipment is still under the manufacturer's warranty, it should be sent to the manufacturer for repair. After the warranty period, the equipment can be repaired by maintenance contract or by Traffic Operations Division (TRF) personnel, if the district does not have a qualified bench technician. To minimize down time, spare units should be kept in stock for use while equipment is shipped for repair.

Section 2

Coordinated Operation

Introduction

Traffic signals can operate at an independent intersection or as part of a coordinated system. The traffic signals can be set up to operate in the fully actuated mode, in fixed time mode, or in a flashing mode of operation. How a signal is operated determines its effectiveness in reducing delay and increasing safety. Signal operation also influences public acceptance.

Coordinating Operations with Other Jurisdictions

The operation of TxDOT traffic signals often crosses jurisdictional boundaries. For this reason, it is often necessary to connect or operate TxDOT traffic signals with signals and control devices maintained and operated by other jurisdictions.

Agreements. If coordination across jurisdictional boundaries is accomplished by synchronizing time clocks (time-based coordination), then no agreement is necessary. If the coordination involves one jurisdiction operating (setting the timing) or maintaining (opening a cabinet for maintenance purposes), then a formal agreement between the entities is required. For information on agreements, see [Chapter 2](#) of the *Traffic Engineering Agreements Volume* of the *Traffic Operations Manual*.

Advantages of Coordinated Operation

Traffic signal systems are designed to minimize delay. An individual intersection operates most efficiently when it is allowed to respond to traffic demand in a fully actuated mode. Fully actuated operation allows the traffic signal to adjust the cycle length and phase split times on a cycle-by-cycle basis.

At all intersections, vehicles tend to group into “platoons.” Once a platoon is established, delay can be reduced by keeping the platoon moving through adjacent signals. The coordination of traffic signals (operating more than one signal in a system) can provide smooth progression along an arterial.

Drawbacks of Coordinated Operation

Operating traffic signals in a coordinated mode does have some drawbacks. The coordination of the system may further delay some minor traffic movements.

Determining Effectiveness of a Coordinated Operation

Several factors determine how effective a coordinated traffic signal system can be. These factors should be considered when determining if a signal should be operated independently in a fully actuated mode or as part of an arterial system. These factors include:

- ◆ distance between intersections
- ◆ system design speed and posted speed
- ◆ required cycle length
- ◆ required pedestrian phases.

Section 3

Preemption

Preemption by Railroad Equipment

Traffic signals near railroad grade crossings can be connected to the railroad equipment to initiate a traffic signal preemption sequence (usually flashing operation — see [Section 4](#) of this chapter). The railroad installs sensors on the tracks that send an electrical input to the traffic signal controller as the train passes over the sensors.

When To Use. Preemption of a traffic signal by the railroad signals is required if the traffic signal is at an intersection that is within 60.96 m (200 feet) of a railroad grade crossing. Preemption should be considered wherever traffic may back up over the crossing due to traffic signals or other traffic congestion.

Traffic signal preemption requires an agreement with the railroad. For more information on railroad agreements and preemption, see the *Railroad Operations Volume* of the *Traffic Operations Manual*.

Types of Railroad Preemption. Preemption of a traffic signal by railroad equipment may be either “simultaneous” or “advance.” These terms, which are used by the railroads, are explained in the *Railroad Operations Volume* of the *Traffic Operations Manual*.

Preemption by Emergency Vehicles

Various mechanisms may be used to preempt traffic signals so that emergency vehicles are provided with safe right of way as soon as practical. This type of preemption is typically used at intersections adjacent to fire stations and on commonly traveled routes. Communication with the traffic signals may be provided by direct wire, modulated light, or radio. The agency requesting the preemption is normally responsible for supplying the interconnect and any additional hardware required for the preemption. Agreements are not required.

Multiple preemptions are allowed at the same location. Priority must be given to each preempt. Railroad preemption always overrides emergency vehicle preemption.

Section 4

Flashing Operation

Introduction

All traffic signals are programmed to operate in the flash mode for emergencies. Signals may also operate in maintenance flash, railroad preemption flash, or scheduled operational flash modes.

The type of flash used (all-red or yellow-red) must be considered carefully. Driver expectation is an important factor. Drivers are conditioned to react to situations through their experiences. Mixing the types of flash can confuse drivers if they are accustomed to the all-red flash. The benefits of operating a mixed color flash must be weighed against the disadvantages. Violation of driver expectation can be a disadvantage of a mixed color flash.

Emergency Flash

Emergency flash mode is used when the conflict monitor senses a malfunction. Emergency flash should use all-red flash exclusively.

Maintenance Flash

Maintenance flash mode can be programmed for the operation of the intersection during routine maintenance. Yellow-red flash can be used if the main street traffic is significantly more than the minor street traffic.

Railroad Preemption Flash

When a traffic signal is preempted by a train, flashing operation may be used while the train is going through the crossing. Either all-red flash or yellow-red flash can be used.

Scheduled Flash

Traffic signals can operate in scheduled flash mode as a time-of-day operation (nighttime flash). Nighttime flash can reduce delay at intersections operating in the fixed time mode. Scheduled flash mode typically uses the yellow-red flash type operation. Nighttime flash should not be used at fully actuated intersections unless all other intersections in the area operate nighttime flash. Again, driver expectation is a major factor in this decision.

Left Turn Flash

When a traffic signal has left turn signal heads the type of flash operation must be considered. If using an all-red flash operation, the left turn signal heads should flash red. If using a yellow-red flash operation, the left turn signal heads should flash red for both the yellow flash direction and the red flash direction.

Chapter 5

Traffic Signal Projects

Contents

This chapter contains the following sections:

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Section 2 — Projects Installed by the State	5-7
Section 3 — Plan Requirements for PS&E.....	5-12

Section 1

Overview

Introduction

This chapter explains traffic signal project funding and programming, methods of construction, submission requirements, and project construction. The submissions consist of information gathered during the traffic study and include various forms, graphs, sketches, plans, and other justification data.

Division Responsibilities

The Traffic Operations Division (TRF) has primary responsibility for reviewing projects solely involving traffic-related work such as the installation of traffic signals. This responsibility includes contract PS&E review and process for letting. Contract projects in which traffic-related work accounts for a minor portion of the work are usually the primary responsibility of the Design Division (DES), with review assistance provided by TRF.

Authorization Request Form

Districts use the Traffic Signals Authorization Request Form to recommend the type of traffic signal control to install at a particular location, the method of accomplishing the work, the warrants upon which the authorization was based, and the funding source. When executed by the district, the form also serves as:

- ◆ authorization for the existence of the signal *and*
- ◆ authorization to do the work under certain programs where work authority has not been previously granted.

Districts are authorized to program projects directly with the Transportation Planning and Programming Division (TPP). In order to obtain a valid **control-section-job (CSJ)** number to establish a project, the district must submit a signed Traffic Signal Authorization Form to TPP.

Signature Requirements. The following officials' signatures are required on the Authorization Request Form:

- ◆ recommendations by district traffic section
- ◆ approval by the district engineer.

Disposition of Paperwork. TxDOT policy requires districts to keep all relevant paperwork in their files. Traffic engineering data need *not* be submitted to TRF. Only a copy of the signed Authorization Request form needs to be submitted to TRF for permanent filing.

Form Available. A sample Traffic Signal Authorization Request Form is provided in Appendix A of the hard copy print version of this manual. This sample form may be

photocopied as necessary. Copies may also be obtained from TRF. In the on-line version of this manual, an MS Word version of this form may be opened and printed out by clicking on the following file name: [TFF-TSAR](#).

Recommending Against Installation

When the district's traffic study indicates that a traffic signal is not needed, the district should notify the requesting party, by letter, that a traffic signal installation is not recommended. In unusual cases, the district may wish to submit their traffic study to TRF for review and comment prior to notifying the requesting party of the study results.

Marginally Warranted Signals

A signal is “marginally warranted” if the traffic study data obtained from the location barely meet the minimum criteria for one or more of the *Texas Manual on Uniform Traffic Control Devices (TMUTCD)* warrants. The engineer must use his or her judgment to determine if installing a signal at a marginally warranted location would be in the best interest of the traveling public.

Research (Research Report 1350-1F) suggests that signalizing a marginally warranted location in a low speed (less than 40 mph) rural setting can significantly reduce crashes at the location. This is only true if the location has experienced more than 2 crashes per year over the past 5 years and if the location has experienced more than 0.8 right angle crashes per year over the past 5 years. In all other instances, installing a marginally warranted signal could result in a higher number of crashes.

Removal of Traffic Signals

Although the original installation of a traffic signal may be based on the satisfaction of one or more warrants and other factors, changes in traffic flow over time may reduce the effectiveness of traffic signal control. When this occurs, it may be appropriate to remove a traffic signal. Neither the *TMUTCD* nor the National *MUTCD* contain specific warrants for the removal of traffic signals. The only *MUTCD* guidance relative to signal removal is a statement that a signal should not continue in operation if it does not meet any of the warrants. However, it is possible that a signalized intersection that does not meet any of the warrants will meet at least one warrant after the signal is removed (due to increases in crashes, delay, or traffic patterns). Therefore, the removal of a traffic signal requires engineering judgement.

Due to the expense associated with the removal and possible reinstallation of a traffic signal, the following steps should be followed prior to the removal of a traffic signal:

1. The traffic signal should be placed in flashing operation reflecting two-way or multi-way stop control, as appropriate.
2. If, after an extended period of flashing operation, intersection operation and safety is acceptable, the signal should be deactivated and STOP signs should be installed on the appropriate approaches. Signal deactivation can be accomplished by covering the signal heads, turning them face down, or removing the signal heads completely. Signal related signing should be removed from the intersection. The signal poles, mast arms, and span wire should be left in place.
3. After an extended period of acceptable sign control operation, the signal poles, mast arms, and span wire should be removed.

NOTE: TRF should be consulted for guidance when removal of a traffic signal is being considered.

City Traffic Signal Installation Using Local Funds

When a city of 50,000 or greater population (latest federal census) desires to install a traffic signal using local funds within its corporate limits on a highway of conventional design which is on the state highway system, TxDOT must conduct a traffic study to determine

- ◆ if there is a need
- ◆ if warrants are met
- ◆ if the proposed installation should be authorized.

When the district engineer approves the project by signing the Traffic Signal Recommendation Authorization Form, the district sends a copy to the Traffic Operations Division (TRF) for permanent filing. The district should then forward a copy of the signed authorization form to the city to serve as their record of approval for the proposed traffic signal installation.

Project Cancellations or Change

If for any reason the work from an approved project is not to be performed or the method of performing the work is to be changed (such as from state forces to contract or vice versa), the district should advise DES, TRF, and if necessary, the Transportation Planning and Programming Division (TPP).

Section 2

Projects Installed by the State

Introduction

This section covers projects installed by the state, which includes all projects using state administered funds. Depending on the type of project, construction may be accomplished using state forces, contract forces, or city forces. These projects generally fall under the following categories:

- ◆ highway safety projects funded through the Hazard Elimination Program
- ◆ other federal-aid projects funded through:
 - Interstate Construction
 - National Highway System
 - Surface Transportation Program
 - Congestion Mitigation and Air Quality Improvement
- ◆ projects funded under state construction programs
- ◆ projects funded under state maintenance programs
- ◆ projects funded using third party funding (such as city, county, or private entity).

Program choice is often dependent on the scope of the proposed work and whether or not the installation is urgently needed.

Programming

Hazard Elimination Safety (HES) Projects. Highway safety projects are funded under the Hazard Elimination Program, which is part of the Highway Safety Improvement Program funded by the Surface Transportation Program. (For HES program details, see [Chapter 2](#) of the *Traffic Accident Information and Hazard Elimination Program Volume* of the *Traffic Operations Manual*.)

Other Federal Aid Projects. Districts should program all proposed federal-aid projects and assign preliminary **control-section-job (CSJ)** numbers prior to conducting traffic studies. Once the project is programmed, all costs incurred in performing the traffic study should be charged to a project CSJ number for the purpose of documentation for federal reimbursement.

(continued...)

Programming (*continued*)

State Funded Construction Projects. Districts obtain work authority for projects funded under state construction programs by programming them through the Transportation Planning and Programming Division (TPP). It is not advisable to program state forces for these projects. Although work authority is provided through an approved program, financing comes from the district's maintenance budget. Construction program funds are applied only to contract work.

State Funded Maintenance Projects. Installation of traffic signals can be accomplished using maintenance funds. A maintenance contract can be let to purchase and install traffic signals. Maintenance funds may also be used to purchase equipment, and state, city, or county forces can be used for installation.

Agreements

For details concerning the securing and processing of traffic signal agreements, see [Chapter 2](#) of the *Traffic Engineering Agreements Volume* of the *Traffic Operations Manual*.

Three-Party Funding. When securing funds from a private entity to install a traffic signal, a three-party agreement is necessary. The third party in these agreements must be the relevant city or county. For details concerning content and execution of these agreements, contact the Contract Services Office (CSO).

Method of Construction

HES Projects. Depending on circumstances, hazard elimination safety (HES) projects may be constructed using either state forces or let to contract. State forces may be used if the district has adequate equipment and manpower to perform the work; however, financing comes from the district's maintenance budget, even though work authority is provided through an approved program. Contract forces may be used if the work involved is of a specialized nature or if the district's work load is such that the proposed work cannot be performed by state forces. It is usually not in the district's best interest to receive local bids, since the Construction Division (CST) is already equipped and staffed to handle lettings on a statewide basis and can do so with no additional burden placed on district personnel to administer the letting procedures locally.

Other Federal Aid Projects. All projects financed using federal-aid funds should be let to contract unless there are valid reasons to provide other methods of construction, such as state or city forces. Projects may be constructed by state or city forces if it can be justified to the FHWA that this method of construction is in the public interest and is cost-effective. The district should be aware that any force account items provided by the state will be charged to the district maintenance budget. Federal reimbursement for these items is not applied back into the district's account, but is placed in TxDOT's general revenue accounts. City force account work, however, is paid initially from state construction funds, which are reimbursed directly by federal funds, because the city is considered to be a contractor for the state.

State Funded Construction Projects. State funded construction projects should go through the construction letting process.

Submission Requirements

For all types of projects, submission requirements vary depending on whether construction is to be accomplished by state forces or statewide contract. The differences are explained under the following two subheadings.

Submission Requirements for State Forces Projects

If the project will be constructed using state forces, then the district may submit the project plans to TRF. The submission should include:

- ◆ a letter of transmittal
- ◆ the plans (2 copies) (see Section 3 of this chapter for information to be shown on plan sheets)
- ◆ plan title sheet tracing signed by the district engineer.

After reviewing the plans, the Traffic Operations Division director or a designated representative signs the title sheet as a record of concurrence and returns it to the district.

Submission Requirements for Projects Let to Statewide Contract

If the project will be let to statewide contract, then the district submits the project plans to the Design Division (DES). The PS&E submission should include:

- ◆ PS&E supporting documents required by DES's *Plans, Specifications, and Estimates Preparation Manual*.
- ◆ plan tracings (see Section 3 of this chapter for information to be shown on plan sheets)
- ◆ prints of plan tracings (3 sets)
- ◆ general notes and specification data sheet
- ◆ a Notice of Financial Clearance form (available from the General Services Division [GSD]) signed by the district engineer verifying the existence of sufficient cash in the district's maintenance work budget to cover payments to the contractor when they become due.

On federally funded projects with federal oversight, TRF forwards the PS&E submission to the FHWA for their review and concurrence after it has been reviewed by the appropriate TxDOT divisions.

NOTE: State force account items or a proposal to supply the contractor with materials must receive FHWA approval prior to letting.

Change of Construction Method

If, after programming a contract project in a state construction program, the district elects to accomplish the work by state forces, the procedures for submission of project plans, construction, and project close-out must be followed. The district should notify the Design Division (DES) and TRF of the decision to change the method of construction. Any state forces work will be charged to the district maintenance work budget, even though the project was originally included in a state construction program. However, the funds originally set up in the program for the project remain available to the district for substitution of other projects which were not originally programmed and which qualify by work category. Substitutions of this nature must be coordinated through the Transportation Planning and Programming Division (TPP).

Letting

Contract letting — which includes the advertising, preparation of proposals, furnishing of proposals to prospective bidders, etc., and preparation of the contract award or rejection by Commission minute — is handled in Austin.

Construction

State Forces. For projects using state forces, the district may proceed with construction after the Traffic Operations Division (TRF) has approved the project plans.

Contract Forces. For projects let to contract, the Construction Division (CST) issues an “Authorization to Begin Work” or “Work Order Authorization” upon award of the contract by the Commission and the signing of the contract.

Shop Drawings

Traffic Signal Poles. Shop drawings for non-standard traffic signal poles should be submitted to the project engineer. The project engineer reviews the shop drawings for general design features and then forwards them to the Design Division (DES) for review and approval of the structural design, fabrication, and erection details.

Lighting Poles. Shop drawings for lighting poles should be reviewed and approved at the district level. If further review is desired, the shop drawings should be sent to DES.

Signs. If roadside traffic signs (such as SIGNAL AHEAD signs) will be installed in conjunction with a traffic signal or safety lighting project, the shop drawings for the sign supports should be reviewed and approved at the district level.

Changes on Contract Projects

Change Orders. If it becomes necessary to change design, correct errors in plans, modify specifications, or extend project limits and the total value of the change order is greater than

\$100,000, then a change order request must be submitted to the Construction Division (CST) (see the *Contract Administration Handbook for Construction and Maintenance Projects* for details). Change order requests involving force account items on contract projects should also be submitted to CST. During the processing in Austin, the Traffic Operations Division (TRF) reviews the change order request.

Supplemental Agreements. A supplemental agreement is required to pay the contractor for any necessary extra work on a unit basis. In most cases, a change order request is also required. The supplemental agreement should be submitted to CST. During processing in Austin, TRF reviews the supplemental agreement.

Changes on City Force Projects

Change Orders. If, on a project constructed by city forces, it becomes necessary to make substantial design changes, correct errors in plans, or extend project limits on a project, the district should submit a change order request to CST.

Supplemental Funds. If it becomes apparent that the project will overrun the authorized funds, a request for additional funds should be made.

Project Close-out

State or City Forces. For close-out of projects constructed with state or city forces, the district should submit the final plans to the General Services Division (GSD) along with a reproduction order for three sets of prints. These prints are charged to the project. If the district desires additional copies, a separate reproduction order should be submitted. The cost of the additional copies will be charged to the district's overhead account.

Contract Forces. For close-out of projects constructed with contract forces, the cost records and final plan tracings should be handled in accordance with the requirements of CST's *Contract Administration Handbook for Construction and Maintenance Projects*.

Section 3

Plan Requirements for PS&E

Introduction

This section describes the sheets that should accompany submissions of plans, specifications, and estimates (PS&E). Depending on the type and size of a project, some of the sheets described may be combined or eliminated. (For additional information, see The Design Division's *Plans, Specifications, and Estimates Preparation Manual*.)

Data for Plan Preparation

The basic data used in preparing the plans can be found on the condition diagram and the design layout sketch submitted with the recommendations. These sheets plus additional information, such as the exact location of all utilities, should be available when preparing the detailed plans.

Affected Utilities. Negotiations with affected utilities must be started upon approval to begin plans for a project so that any utility adjustments can be made promptly when work begins.

Survey Data and Photographs. All survey data should be kept in a neat and detailed form so it can be referred to at any time. By detailing all information and obtaining photographs of the location and special features, unnecessary trips to the location may be eliminated. For this reason, adequate time should be devoted to project surveys and photographs.

Title Sheet

The title sheet must contain the following information:

- ◆ title describing the location and type of installation (for example: “Work Consisting of Installation of a Full Traffic-actuated Traffic Signal”)
- ◆ area map (county, city or both) with the location of the installation circled and noted as “LOCATION OF PROPOSED WORK”
- ◆ project limits, project number, **control-section-job (CSJ)** number, project length
- ◆ index of sheets, including sheet number and title (can be separate sheet)
- ◆ spaces for the following officials’ signatures:
 - city or county officials, as applicable
 - engineer responsible for the preparation of the plans
 - district engineer
 - director, Traffic Operations Division (TRF).
 - other division heads and the FHWA division administrator, as applicable.

Estimate and Quantity Sheet

The estimate and quantity sheet is necessary only for state financed contract projects and federally financed projects.

This sheet should list all bid items for the project. The list should consist of:

- ◆ the estimated bid item quantities, showing a breakdown by control and section and the total for the entire project
- ◆ the specification item number as well as the descriptive code number and alternate number (if applicable)
- ◆ the bid item description (for example: “Installation of Highway Traffic Signals”) and the unit of measurement (for example: L.S., Ea., etc.).

This sheet should also show any state or city force account items and any materials to be furnished to the contractor by the state. (For instructions on plotting the estimate and quantity (E&Q) sheet from ROSCOE, see the Design Division’s *DCIS User Manual*.)

Condition Diagram Sheet

The condition diagram (described in [Chapter 3, Section 2](#) of this manual), which is included with the submission of the district’s recommendations, must also be included in the project plans.

Plan Sheets

The plan sheet (or sheets) must provide a detailed, dimensioned layout of the location. North must be toward the top or left edge of the sheets. Plan sheets must include the following:

- ◆ **existing traffic control** that will remain unchanged (parking, signing, striping, traffic signals, lighting, etc.)
- ◆ **existing utilities**, including indication of ownership as well as a detailed location with respect to roadway and depth below or height above the surface.
If usage is to be made of any part of the utility, notes about such usage are to be included.
If there are a large number of utilities, a separate utilities sheet should be provided to show their locations.
- ◆ **proposed highway improvements** (design, geometrics, pavement type, etc.). Design and operational considerations for traffic signals are addressed in Chapter 4 of this manual. Safety lighting design is covered in the *Highway Illumination Volume* of the *Traffic Operations Manual*.
- ◆ **proposed installation**, including the exact location of all major items of equipment, such as poles, foundation, luminaries, conduit, signal heads and faces, ground boxes, detectors, controllers, etc. shown in detail.
- ◆ **proposed additional traffic control**, such as striping, stop lines, signs, etc.

Elevation Sheets

The elevation sheet (or sheets) should show elevation views for all above ground equipment.

Traffic Signal Elevation Sheets. Traffic signal elevation sheets should include the dimensioned views of proposed mast arm and span wire mounted signal assemblies, above ground detectors, post or bracket mounted signal assemblies, and other similar items. Elevation views of proposed signal equipment should show the exact location of the equipment with respect to the existing roadway and all surrounding facilities. The sheets should also show the following information, when pertinent to the particular elevation view:

- ◆ sign locations and legends
- ◆ overhead utility installations located with respect to proposed signal equipment
- ◆ horizontal and vertical roadway clearances

Utilities Elevation Sheets. Utilities should be checked in detail, and those requiring adjustment should be noted on the utilities elevation sheet, with additional sheets prepared showing proposed relocation.

Detail Sheets

Standard sheets prepared by the Design Division (DES) and the Traffic Operations Division (TRF) and special detail sheets prepared by the district should include sufficient detail to adequately describe all of the following applicable items:

- ◆ poles:
 - signal
 - power
 - luminaire
 - pedestal
- ◆ ground boxes
- ◆ wiring diagrams
 - cable termination (signal, power, and illumination)
 - detector termination
- ◆ conduit and conductor tables
- ◆ detectors:
 - induction loop
 - pedestrian push button
 - other (microwave, acoustic, infrared, VIVDS)
- ◆ concrete foundations:
 - controller
 - poles
- ◆ down-guys (including anchors)
- ◆ vehicle and pedestrian signal head mounting details (vertically or horizontally mounted with or without backplate)
 - span wire
 - mast arm
 - pedestal or post top
 - short bracket

- ◆ phasing sheet showing:
 - signal location
 - signal indications
 - phasing diagram (see [Figure 5-1](#))
 - signal sequence plan table (see [Figure 5-2](#))
 - flashing operations
 - preemption operation (when applicable)
- ◆ work area protection, including any or all of the following:
 - standard barricade and construction sheets and traffic control plan prepared by the Traffic Operations Division (TRF)
 - construction detour and barricade location sheets
 - plan notes pertaining to work zone and sequence of work, if applicable.

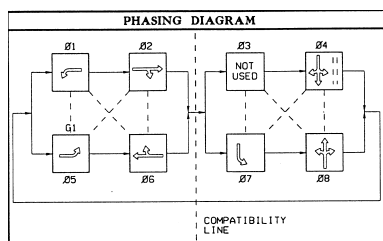


Figure 5-1. Typical phasing diagram.

Figure 5-2. Typical sequence plan table. [For MS Word version, click [this file name:SEQUENCE.](#)]

Specifications

The specifications submitted with each set of project plans for a state financed contract project or for any federally financed project must be adequate to provide for the purchase of all necessary equipment to be installed as well as other materials which must be used in completing the installation. The manner and method of installation must also be addressed. Reference should be made to the TxDOT's *Standard Specifications for Construction of Highways, Streets and Bridges*, as applicable.

Occasionally special specifications are needed to procure equipment or define items of work not explicitly covered by the standard specifications. As existing specifications evolve through a history of use, special provisions to these specifications are developed to reflect any changes to current practice or special need. Contact TRF for the latest versions of the special specifications.

PS&E Paperwork

PS&E paperwork may include, but is not limited to the following:

- ◆ PS&E submission data
- ◆ general notes
- ◆ specification list
- ◆ estimate.

For information on all paperwork that needs to be submitted with a PS&E package, see the Design Division's *Plans, Specifications, and Estimates Preparation Manual*.

Appendix A

Forms

Introduction

This appendix lists the forms described in this manual. In the hard copy print version of this manual, this appendix contains samples of each form. These samples may be photocopied as necessary. Copies may also be obtained from the Traffic Operations Division (TRF).

MS Word versions of some of the forms are accessible through the on-line version of this manual, as indicated in the following list.

List of Forms

This appendix contains the following forms in the following order:

Forms Pertaining to Traffic Signals			
Form Name	Hot Text Link (on-line only)	# of Pgs.	Described in Chap.
Traffic Signal Authorization Request*	TFF-TSAR	1	2, 5
Vehicle Volume Field Sheet		1	3
Vehicle Volume Field Sheet (for Five-way Intersection)		1	3
Vehicle Volume Summary Sheet*	TFF-VVS	1	3
Vehicle Volume Summary Sheet (for Five-way Intersection)*	TFF-VVS5	1	3
Pedestrian Group Size Study*	TFF-PGD	1	3
Pedestrian Delay Time Study*	TFF-PGD	1	3
Traffic Survey – Count Analysis Form*	TFF-TSCA	6	3
Pedestrian Volume Field Sheet		1	3
Pedestrian Volume Field Sheet (for Five-way Intersection)		1	3
Pedestrian Volume Summary Sheet*	TFF-PVS	1	3
Pedestrian Volume Summary Sheet (for Five-way Intersection)*	TFF-PVS5	1	3
Intersection Delay Study Field Sheet*	TFF-IDS	1	3
* Indicates that an MS Word version is available through the on-line version of this manual.			

Notes:

Appendix B

Determination of Need for Traffic Control at School Crossings

Introduction

The determination of need for traffic control at a school crossing involves a five step process. This appendix explains the five steps and provides example data and calculations for a hypothetical crossing.

The Pedestrian Group Size Study form and the Pedestrian Delay Time Study form provide a means of documenting the process. Blank samples of these two forms are contained in Appendix A of the hard copy version of this manual. The on-line version of this manual provides access to MS Word versions these forms. Districts may also devise their own forms for this purpose.

Be sure that the basic information concerning the time of the study and the location is recorded on the forms.

EXAMPLE:

Study date: 9-16	Time from: 3:15	to: 4:00	Location: S.H. 359 & Rose
Crosswalk across: S.H. 359	Curb-to-curb or road width (ft): 64 ft.		
Divided roadway? Yes <input type="radio"/> No <input checked="" type="radio"/>	Width of island:		

Figure B-1. Example basic information concerning time and location of study.

Step 1. Pedestrian Count

Pedestrian counts should be made on a normal school day during the heaviest hours of crossing activity in the morning or afternoon — preferably both. A tabulation should be made of the number of children crossing the roadway and the time required for the group to cross. It is assumed that up to five pedestrians will walk abreast when a group crosses the roadway. The number of rows is determined by dividing the group size by five. Note that the number of rows is taken as a whole number, since even one pedestrian in excess of an even five will make an additional row, requiring extra clearance time.

(continued...)

Step 1. Pedestrian Count (*continued*)

EXAMPLE:

Time	Children Crossing	No. of Rows	Time	Children Crossing	No. of Rows	Time	Children Crossing	No. of Rows
3:15	1	1	3:46	10	2	4:00	1	1
3:17	1	1	3:47	8	2			
3:20	4	1	3:48	15	3			
3:21	5	1	3:49	15	3			
3:24	4	1	3:50	17	4			
3:28	1	1	3:51	7	2			
3:30	2	1	3:53	6	2			
3:34	4	1	3:55	9	1			
3:40	6	2	3:56	3	1			
3:45	4	1	3:58	2	1			

Figure B-2. Example pedestrian count.

Step 2. Determination of the Number of Rows *N*

The total number of groups is found by adding up the number of groups that crossed the roadway. This number is then multiplied by 0.85 to obtain the 85 percentile cumulative number of groups (*C*). *C* is then compared to the CUMULATIVE column, where the cutoff point is chosen. The CUMULATIVE column cutoff point is the first number greater than or equal to *C*, as read from the bottom to the top in the column. At the cutoff point the 85 percentile number of rows *N* can be found in the NUMBER OF ROWS column.

EXAMPLE:

Group Size	No. of Rows	Number of Groups		Cumulative	Computations
		Tally	Total		
46-50	10				$C = 21 \times 0.85 = 17.85$, which is the 85 percentile cumulative number of groups. Since 17.85 is between 13 and 18, we choose 18 as the CUMULATIVE column cutoff point.
41-45	9				
36-40	8				
31-35	7				
26-30	6				
21-25	5				Reading across the page gives the 85 percentile number of rows.
16-20	4	1	21	21	
11-15	3	2	20	20	
6-10	2	3	18	18	
1-5	2	11	13	13	
Total Number of Groups:			21	18	<i>N</i> = 2

Figure B- 3. Example determination of the number of rows *N*.

Step 3. Determination of the Adequate Gap Time G

The adequate gap time G is determined from the equation:

$$G = \frac{W}{S} + P + 2(N - 1)$$

Where:

W is the curb-to-curb road width in feet.

N is the 85 percentile number of rows.

S is the average walking speed — assumed to be 3.5 ft./sec.

P is the average perception and reaction time — assumed to be 3.0 seconds

$2(N - 1)$ is the pedestrian clearance time.

EXAMPLE:

$$G = \frac{W}{3.5} + 3 + 2(N - 1)$$

$$G = \frac{64}{3.5} + 3 + 2(2 - 1)$$

$$G = 18 + 3 + 2 = 23 \text{ seconds}$$

Step 4. Pedestrian Delay Time D

Pedestrian delay time is determined by recording the number of gaps with a gap size greater than or equal to the adequate gap time G . (The Pedestrian Delay Time Study form is designed for this purpose.) The number of gaps for a particular gap size is then multiplied by the gap size. Then the total time t of all gaps equal to or greater than G is found by adding up the product of the number of gaps and the gap size. The actual pedestrian delay time D is then found by the equation:

$$D = \frac{T - t}{T}(100)$$

Where T is the total survey time in seconds.

(continued...)

Step 4. Pedestrian Delay Time D (continued)**EXAMPLE:**

Study date: 9-19 Location: S.H.359 & Rose Crosswalk across: S.H.359
 End of survey (to nearest minute): 4:00 P.M. 85th percentile rows — N: 2
 Start of survey (to nearest minute): 3:15 P.M. Roadway width — W: 64 ft.
 Total survey time (minutes) — T: 45 min. Adequate gap time — G: 23.3 secs.

Gap Size (seconds)	Field Study Data	Total	Multiply by Gap Size	Computations
8				$T = \text{total survey time} \times 60$
9				$T = 45 \times 60$
10				$T = 2700 \text{ sec.}$
11				
12				$D = \frac{T - t}{T}(100)$
13				
14				$D = \frac{2700 - 921}{2700}(100)$
15				$D = 65.8\%$
16				
17				
18				
19				
20				
21				
22				
23	III	4	92	
24	IIII I	6	144	
25	III	4	100	
26	IIII II	7	162	
27	II	3	81	
28	III	4	112	
29	II	2	58	
30	II	3	90	
31	II	2	62	
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
Total time of all gaps equal to or greater than G =				921 secs.

Figure B-4. Example determination of pedestrian delay time D .

Step 5. Determination of Need for Traffic Control

Curb-to-curb width (W), pedestrian delay time (D), and the 85 percentile number of rows (N) can be plotted on a graph as shown in **Figure B-5** to determine if control is needed.

EXAMPLE: The graph shown in Figure B - 5 shows that a traffic signal could be justified in the hypothetical example, since point A is above the line $N=2$.

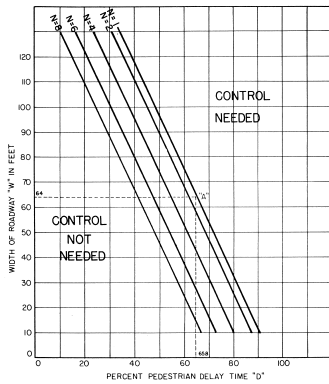


Figure B-5. Determination of need for traffic control at school crossings. Here a traffic signal could be justified, since point A is above the line $N=2$.